

**MARS HABITAT****PRAIRIE VIEW A&M UNIVERSITY**

35-54

160611

p 11

**INTRODUCTION**

The College of Engineering & Architecture at Prairie View A&M University has been participating in the NASA/USRA Advanced Design Program since 1986. The interdisciplinary nature of the program allowed the involvement of students and faculty throughout the College of Engineering & Architecture for the last five years. The research goal for the 1990-1991 year is to design a human habitat on Mars that can be used as a permanent base for 20 crew members. The research is being conducted by undergraduate students from the Department of Architecture.

**OBJECTIVE**

The purpose of this study is to develop a conceptual design for a permanently manned, self-sustaining martian facility to accommodate a crew of 20 people. The goal is to incorporate the major functions required for long-term habitation in the isolation of a barren planet into a thriving ecosystem.

These functions include the living area, research laboratories, medical clinic, greenhouse, command control, materials processing, life support system, power source, and a launch pad. The harsh environment of Mars is not conducive to life as we know it. Cosmic radiation, thin atmosphere, extreme cold, dust storms, and the absence of surface water and food must be overcome for humans to survive on Mars.

**GENERAL CONCEPT**

The general concept of the design is to create a comfortable, safe living environment for the 20 crew members for a stay of 6 to 12 months on Mars. This self-contained environment would accommodate five main facilities: living facilities, working facilities, service facilities, medical facilities, and a greenhouse. The main design task is to focus on the internal layout while investigating the appropriate structure, materials, and construction of these facilities.

Two different concepts, an inflatable structure and a space-frame structure have been investigated.

**MODULAR ASSEMBLY REUSABLE STRUCTURE  
MARS BASE (LAVAPOLIS)****Concept**

Construct inflatable modules in a lava tube, using the modular assembly reusable structure (MARS) system (Fig. 1).

**Site**

The selection of an appropriate site is critical to the long-term success of the Mars base. An equatorial site is most economically accessed from low Mars orbit, and simplifies rendezvous maneuvers. The most striking geological features, Olympus Mons, the largest volcano in the Solar System, and Valles Marineris, the colossal canyon, are located there.

The site chosen for Lavapolis is at the base of Ceraunius Tholus, a 115-km-wide, 22-km-high volcano in Northeast Tharsis at 24°N, 97°W, at the area where an impact crater has pulverized a 2-km-wide channel.

**Assumption**

A lava tube exists in the region described that satisfies the requirement for habitability. It must be accessible, have structural integrity, and dimensions of not less than 200 ft wide, 50 ft high, and 400 ft deep for this proposed scheme.

**Rationale for Construction in a Lava Tube**

The large covered volumes that are naturally created by the flow of molten lava underground that drains away, can provide radiation shielding for the entire base without having to move a lot of dirt. The thermal mass regulates the internal temperature to be relatively constant at any time. The environment is calm year round, minimizing the load on the HVAC system, and is protected against frequent dust storms. The time required to locate and prepare a lava tube for habitation is less than the time it would take to cover a base with 3 ft of soil. Also, the sheltered volume available in a lava tube is much larger than that which can be constructed, and requires less structural mass for the pressurized modules. The basaltic rock of a tube can be processed to form glass structural panels that can be used to seal and pressurize large segments of the lava tube for future expansion.

**Structure**

The modular assembly reusable structure (MARS) system consists of inflatable cylinders supported at the ends with lightweight aluminum rings. The rings are composed of 8 segments, 3 ft wide, which join together to form a 30-ft-diameter circle, and are spaced 30 ft on center. The cylinders are made of pneumatic material and connect the space between two rings, with the same 30-ft diameter. Attaching the circular walls made of pneumatic material to the rings on either side of the cylinder forms on MARS module (Figs. 2 and 3).

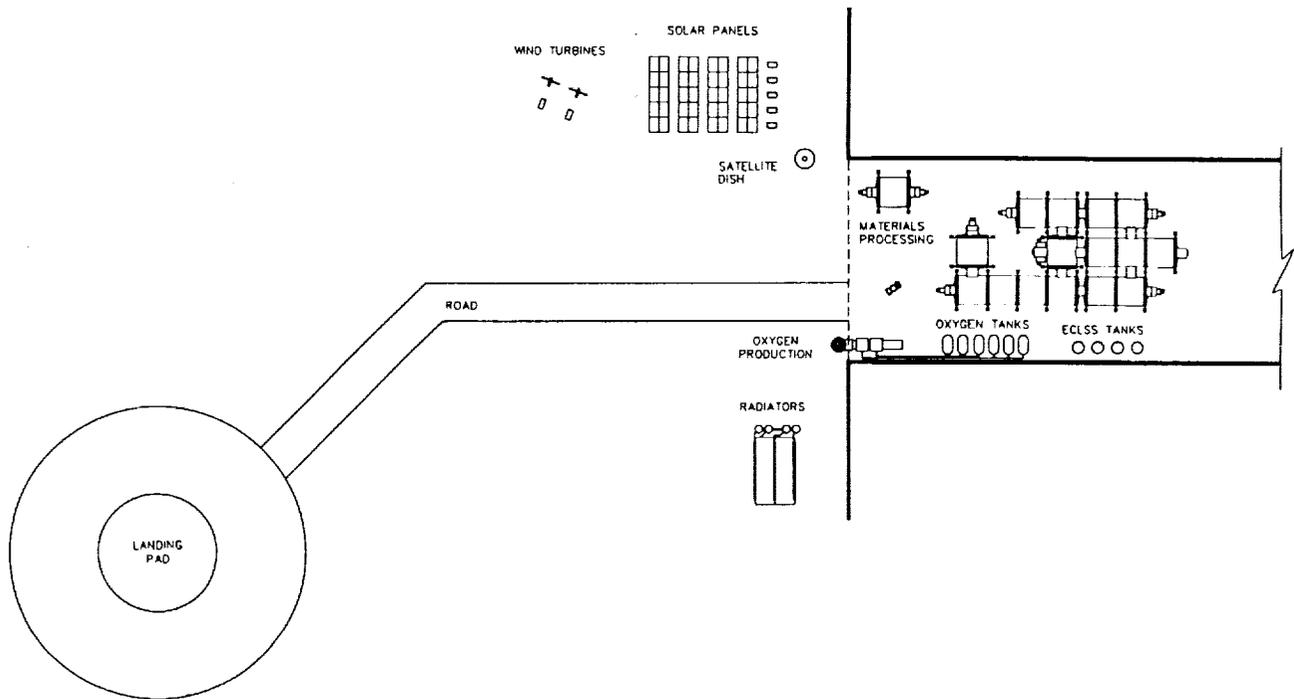


Fig. 1. Site Plan.

The floor joists span the length of the cylinder and connect to a beam spanning the ring. This beam carries the floor loads to the ring, through several short beams, to a column on either side of the ring, then down to the mat foundation. The floor and ceiling heights are variable depending upon functional requirements and can be easily modified as the needs change. Additional cylinders can be connected to the habitat without having to depressurize the existing structure. The MARS system deploys large expandable volumes using reusable, lightweight, modular components, and connections, which require minimum packing space.

#### Architecture (Exterior)

The organization of the base is a linear pattern, corresponding to the geometry of the MARS system, and contextually with the tubular nature of the site. The modules are arranged in a functional composition with resulting aesthetics derived from the orientation of the module's flat round, or convex square elevations, juxtaposed with the columns. The oblong form of adjoining cylinders with the repetitive column spacings resembles a Roman basilica, creating a sense of traditional architecture.

#### Architecture (Interior)

The interior spatial complexities are achieved through the variations in floor and ceiling heights, combined with the arrangement of inflatable furniture and partitions that allow for

long views through several open modules or define small intimate spaces (Figs. 4, 5, and 6).

Level changes of a couple of feet can be made with the use of stairs, while ladders and manual elevators are provided for separations in floors of several feet.

The sizes of internal volumes are similar to those on Earth, because any perception of home is beneficial to the psychological wellbeing of the inhabitants.

There are two means of egress from every module, one of which will lead to an air-lock toward the exterior. A group of modules can be sealed and isolated in case of contamination or fire.

#### Future Expansion

The future expansion of the base will entail the processing of basaltic rock into structural glass panels and connections. Large segments of the lava tube can be sealed and pressurized making it possible to landscape and construct buildings that incorporate architectural styles from around the world to create an international garden city.

### PREFABRICATED SPACE FRAME STRUCTURES HEXAMARS

#### Concept

The concept is to construct a space-frame structure that consists of a central core and secondary modules radiating from

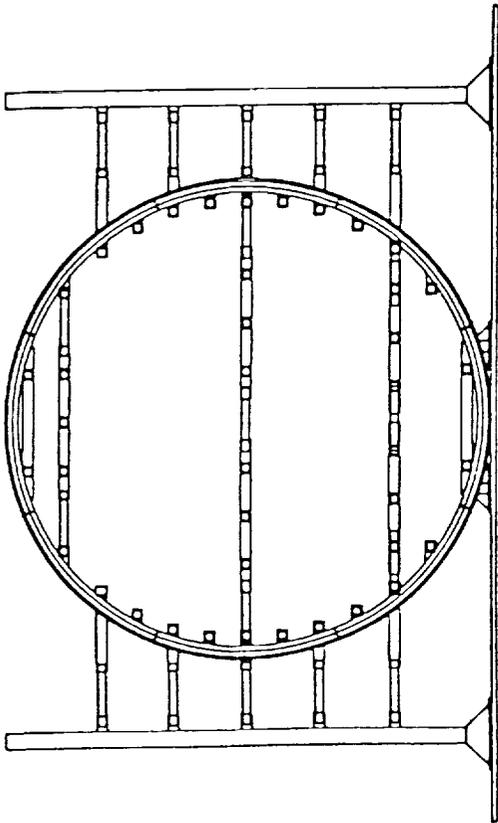


Fig. 2. Cross Section.

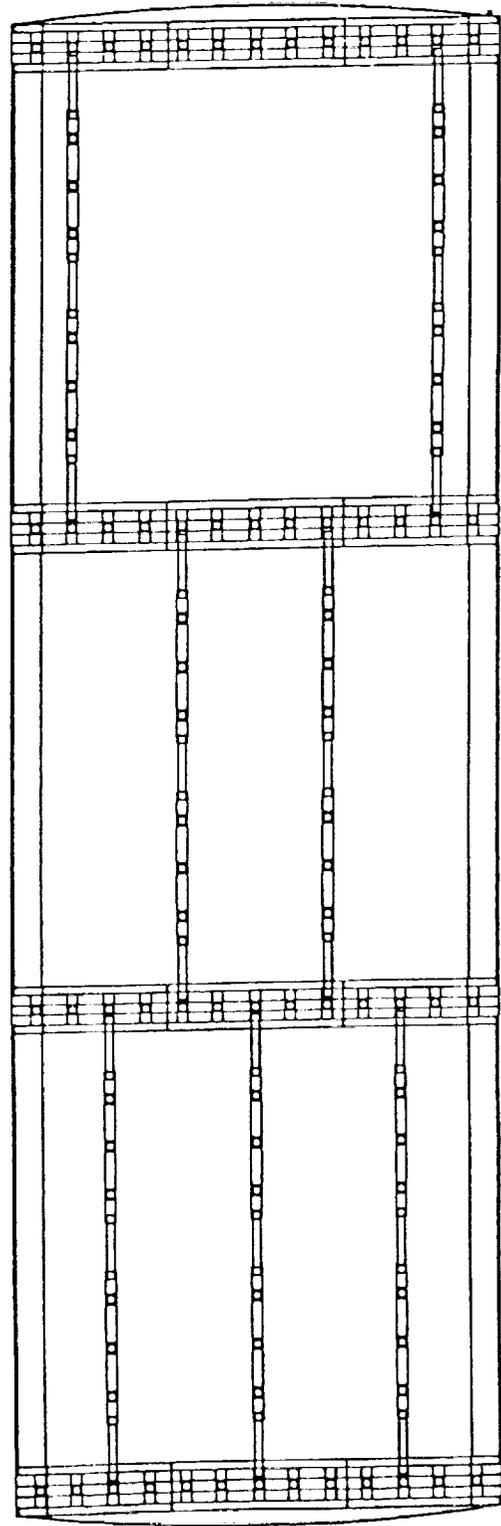


Fig. 3. Longitudinal Section.

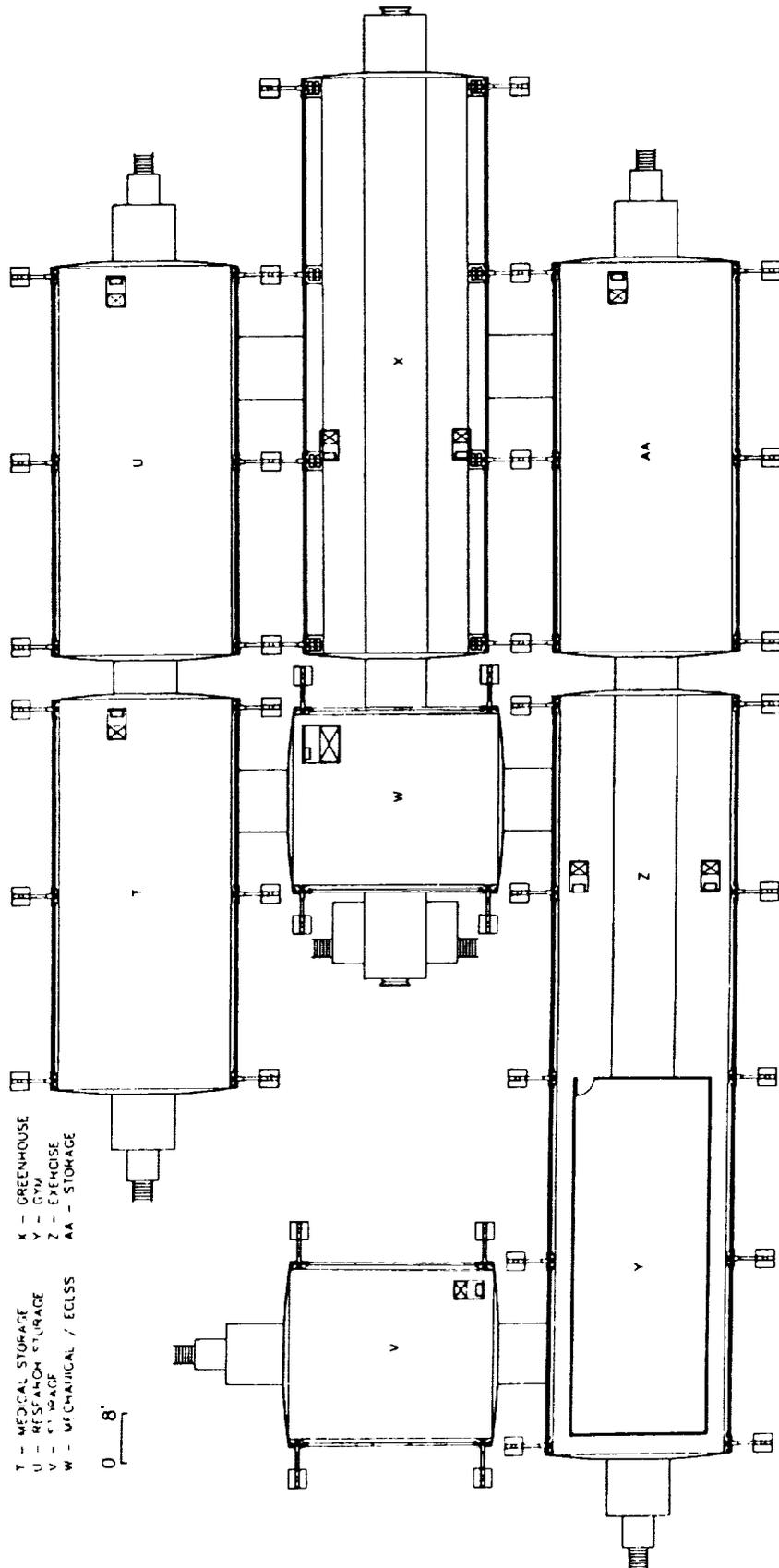


Fig. 4. First Floor Plan.

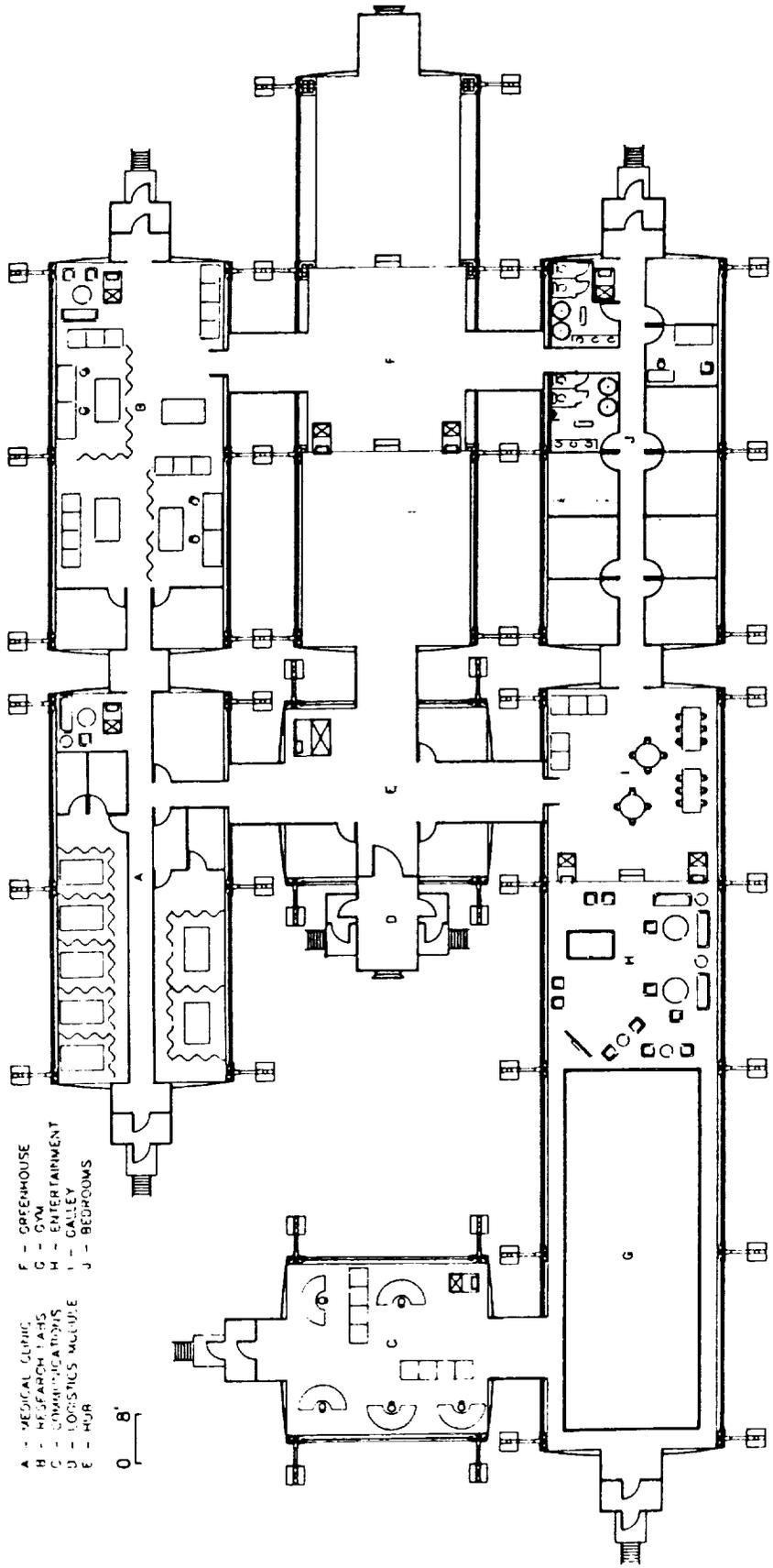


Fig. 5. Second Floor Plan.

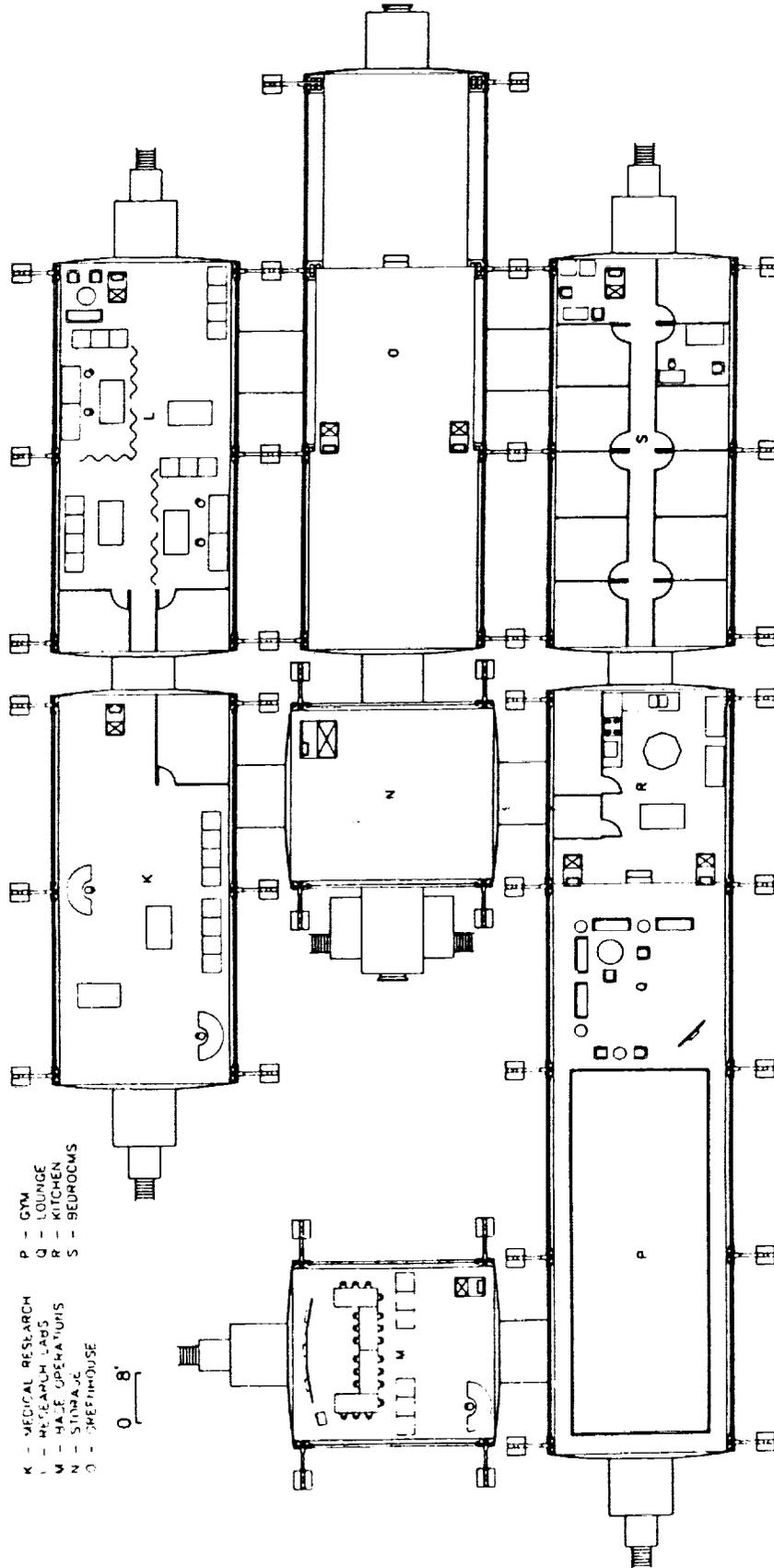


Fig. 6. Third Floor Plan.

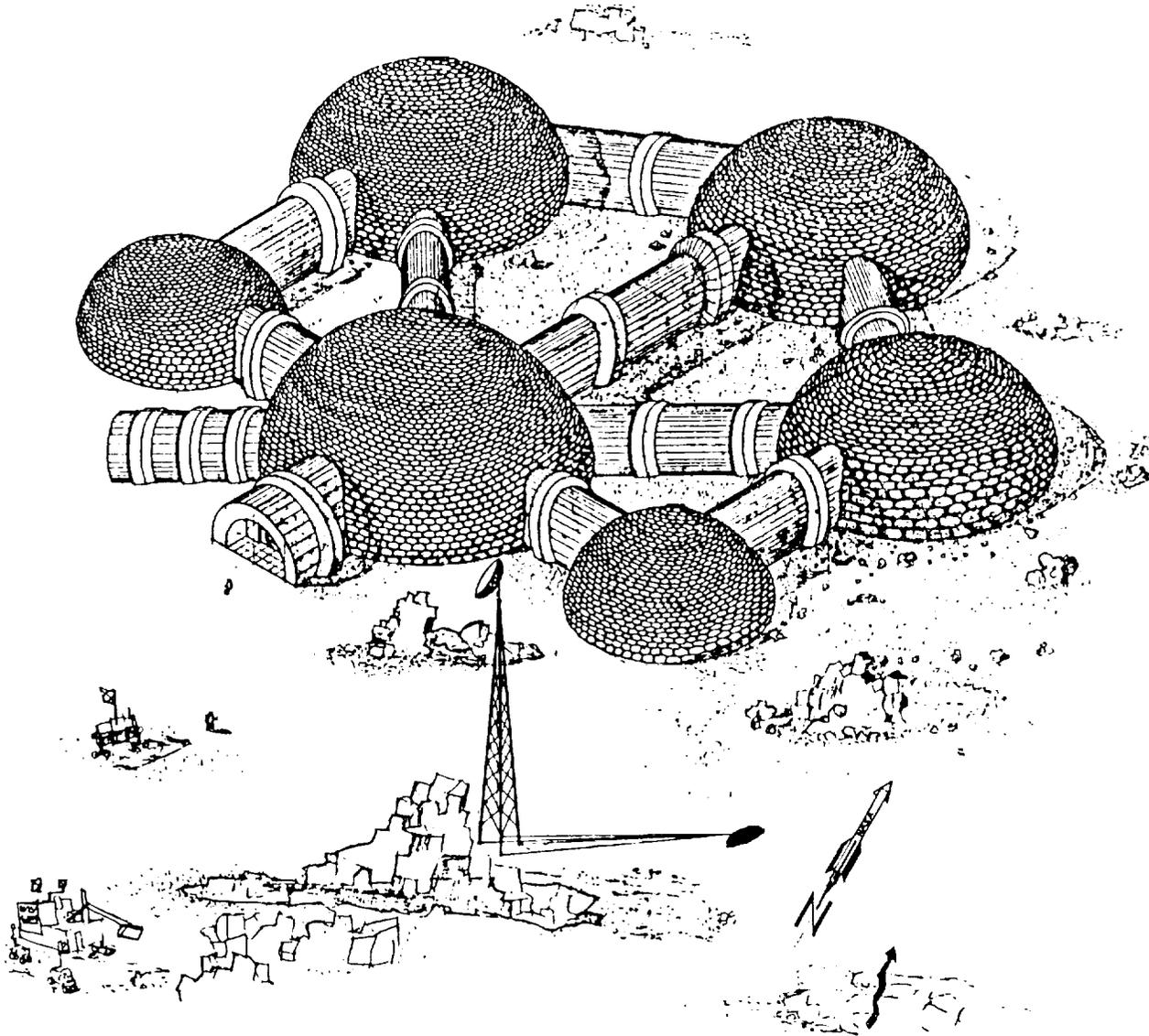


Fig. 7. Isometric of Hexamars.

the core. The sphere-shaped modules will be partially buried below the martian surface. Interchangeable structural members are used in the construction of this habitat (Figs. 7 and 8).

**Site Location**

The site location is 3°N latitude 99°E longitude between Pavonis Mons and Ascraeus Mons. The site is compatible to the angle of the spacecraft entering Mars orbit. It is also close to the equator and has relatively moderate temperature conditions.

**Assumptions**

1. There will be a temporary habitat located near or at the site of an earlier mission that satisfies the requirements for a short-term habitation.
2. The prefabricated space-frame structure, as well as other prefabricated material, will be shipped to the site before the long-term crewmembers arrive.
3. Partial construction and preparation for the long-term habitat will be done by crewmembers or robotics from a previous mission on Mars.

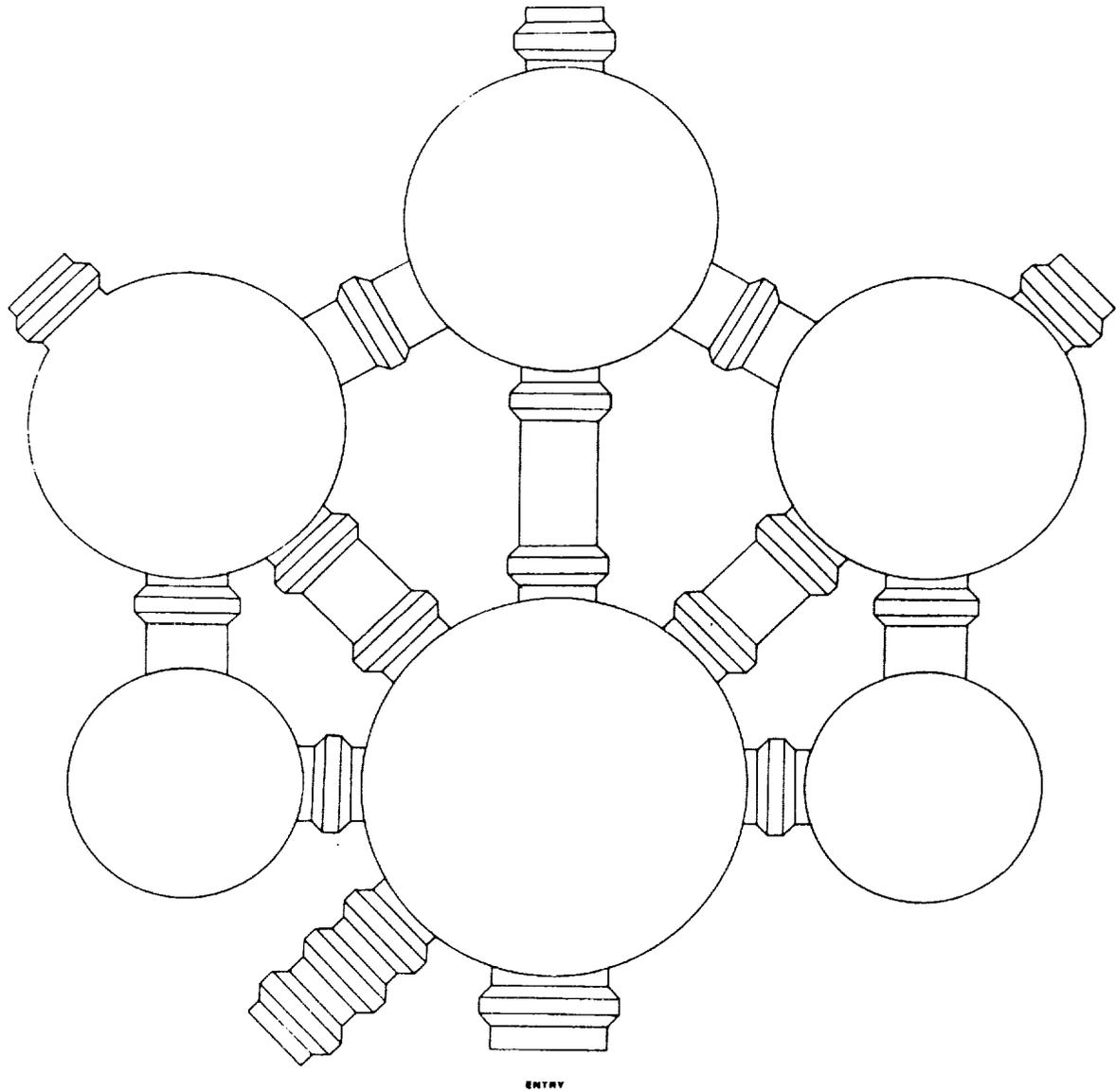


Fig. 8. Roofplan.

4. The construction of the long-term habitat will occur in phases.

#### Structure

The prefabricated frame structures are individual structural members generally fabricated in tubular shapes of metal. Each member is usually stressed axially, either in compression or tension. At the ends of each member, there is a specified connector installed to allow for both construction and expansion.

The internal structure consists of (1) six telescoping hexagonal core columns; (2) six peripheral ribs; (3) radial floor-beams; (4) circumferential joists; (5) intermittent floorjoint; and (6) secondary bracing.

A mat foundation transfers all loading of the interior to the exterior support structure from six hard points.

The module shell consists of prefabricated spare-frame and titanium panels on the exterior, with Kevlar 29 for the interior module shell wall, Nextel for floor panels, and foam-rigidized walls for partition walls.

#### Methods of Construction

##### *Steps of assembly.*

1. Create five holes and grade them for the mat foundation to be set in them.
2. After the self-deploying foundation is in place, the space frame structure is connected to the foundation.

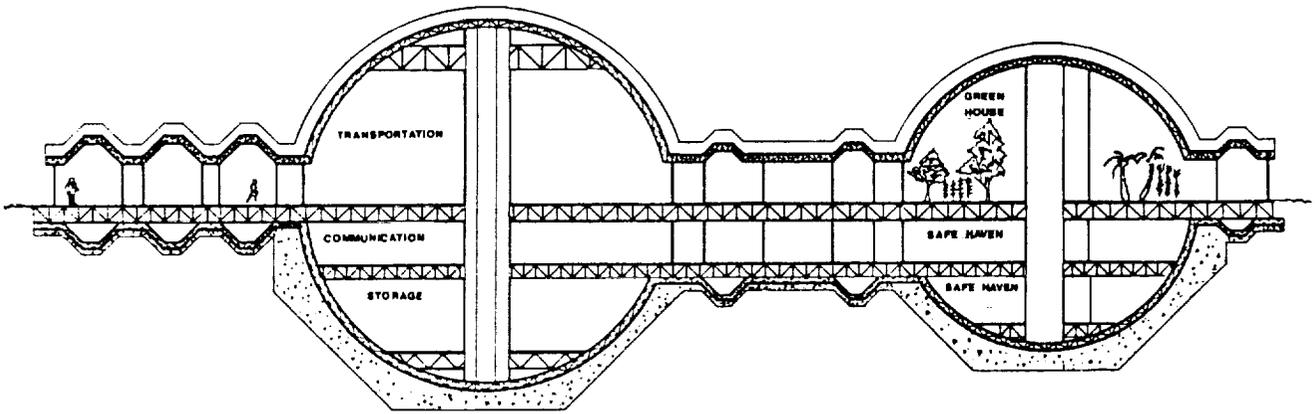


Fig. 9. Section B-B.

### LEGEND

- 1 COMMUNICATION
- 2 BASE COMMAND
- 3 RESTROOMS
- 4 CREW QUARTERS
- 5 MEDICAL CLINIC
- 6 DINING
- 7 KITCHEN
- 8 RESTROOMS & SHOWERS
- 9 SICK BAY
- 10 VEGETATION LAB
- 11 SOIL LAB
- 12 OXYGEN STORAGE
- 1A OFFICE
- 2A CONSTRUCTION EQUIPMENT STORAGE

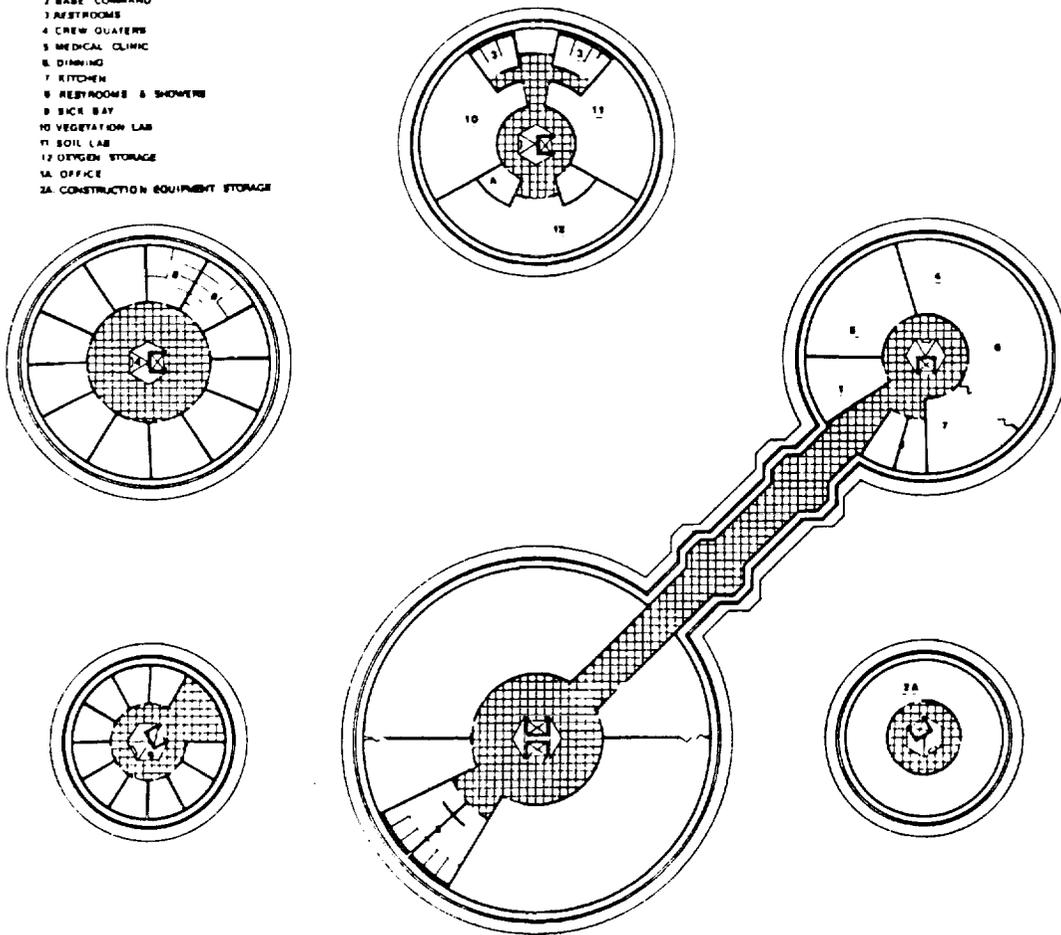


Fig. 10. Plan 3.

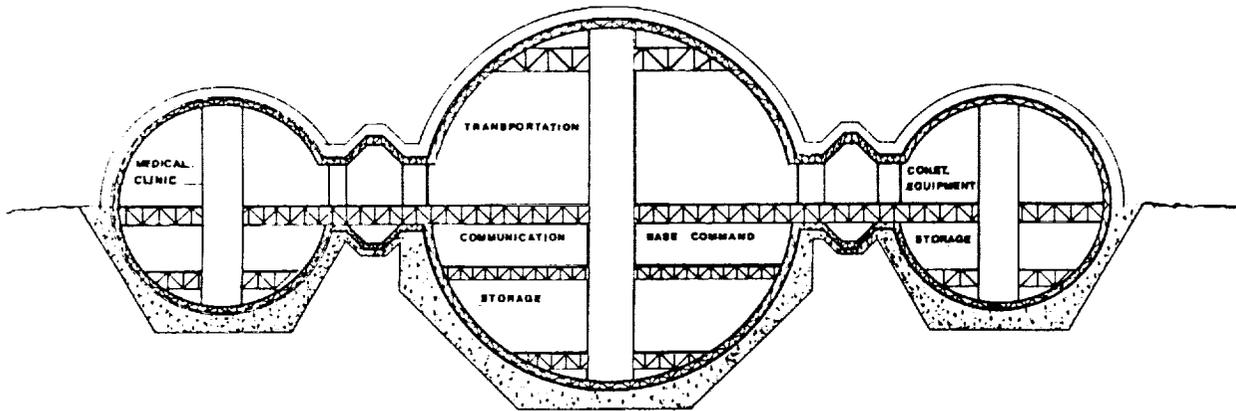


Fig. 11. Section A-A.

### LEGEND

- A TRANSPORTATION
- B WORK AREA CONSTRUCTION
- C GREEN HOUSE
- D OFFICE
- E STORAGE
- F RESTROOM
- G ATMOSPHERIC LAB
- H CHEMICAL
- I EXERCISE ROOM
- J KITCHEN DINNING
- K ENTERTAINMENT
- L DENTAL CLINIC
- M CLINIC AREA
- N RESEARCH
- O OXYGEN STORAGE

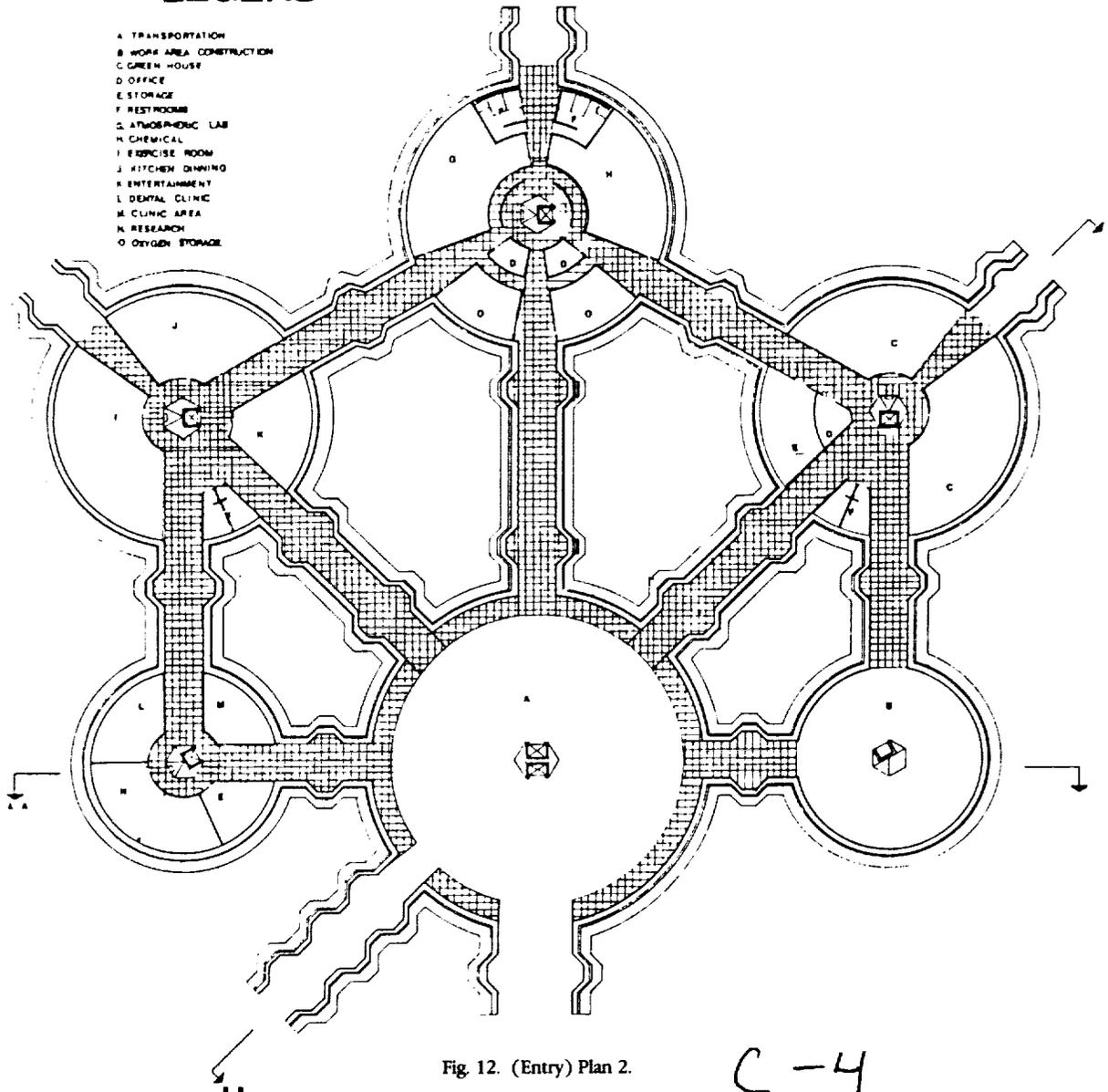


Fig. 12. (Entry) Plan 2.

C-4

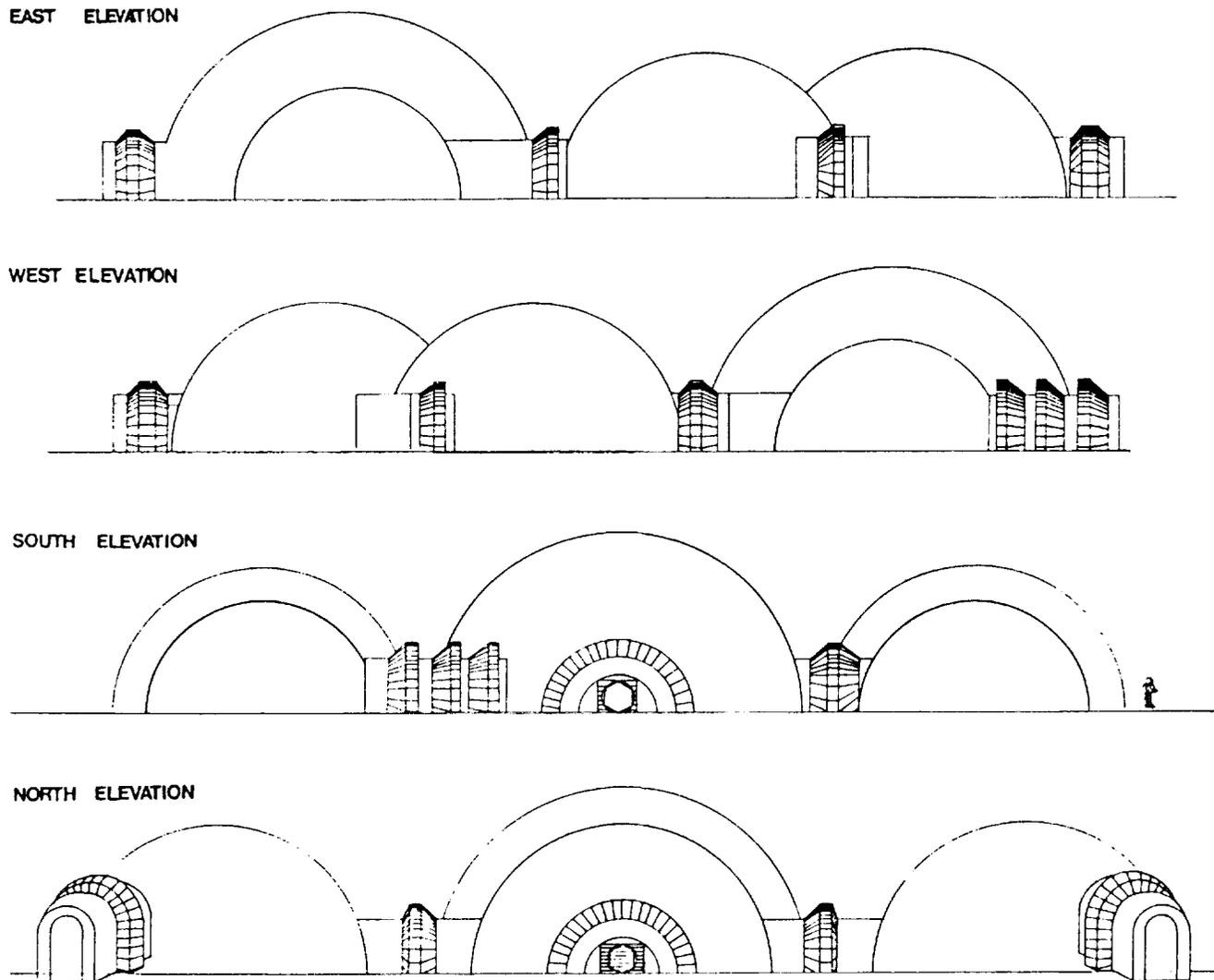


Fig. 13. Elevations.

3. Four columns in the membrane structure are connected to the foundation.

4. The space-frame structure is packaged with the internal telescopic columns, internal framing, and initial life support.

5. As the space-frame structure is pressurized, the Nextel flooring will be put into position.

The construction of the space-frame structure will occur in five phases.

1. Phase 1 is the safe haven, which includes the dining room and kitchen, exercise room, entertainment, crew rooms, and storage (Fig. 9).

2. Phase 2 will be the crew quarters, which includes the medical facilities, bathroom, wardroom, and storage (Figs. 10 and 11).

3. Phase 3 is the transportation bay, which consists of the base command and communication unit, and transportation port (Fig. 12).

4. Phase 4 will be the greenhouse and service facilities. These facilities include plants, animals, oxygen storage tanks, construction equipment, and storage (Figs. 10 and 12).

5. Phase 5 will be the laboratories, which consist of soil, chemical, vegetation, and atmospheric labs and storage (Fig. 10).

#### Future Expansion

The future expansion of the long-term base will entail constructing and adding more prefabricated space-frame modules to the existing long-term base, thereby creating a colony of prefabricated modules with multiple functions (Fig. 13).

#### ACKNOWLEDGMENTS

Project Director and Faculty Advisor is Ikhlas Sabouni, Ph.D. Faculty Advisor is Marshall V. Brown, P.E., Interim Dean. Student participants were Dale Ayers, Woody Bryant, Vernadette Gardner, Brock Harrell, Sherrill Hilton, Ronald Livingston, Damian Ohale, Jose Villanoeva, Ricardo Watson, and David Ways.

